Sensors & Actuators

Lecture 15

Actuators

(or) Corrective Elements

(or) Final Control Elements

Actuators (Corrective/Final Control Element)

- Controlled/Process Variable
- Manipulated Variable
- Responsible for transforming the output of a controller into a change in the process which aims to correct the change in the controlled variable
  - A valve which is operated by the output from the controller and used to change the rate at which liquid passes along a pipe and so change the controlled level of the liquid
  - A motor which takes the electrical output from the controller and transforms it a rotary motion in order to move a load and so control its position.
  - A switch which is operated by the controller and so used to switch on a heater to control temperature

Actuator (in particular)

- *Actuator (term) is used for the part of a correction/final control* element that provides the power
  - A valve might have an input from the controller and be used to vary the flow of a fluid along a pipe and so make a piston move in a cylinder and result in linear motion.
  - The piston-cylinder system is termed an actuator

Pneumatic and Hydraulic Systems

- Process control systems frequently require control of the flow of a fluid.
  - The valves used as the correction elements in such situations are frequently pneumatically operated, even when the control system is otherwise electrical.
  - This is because such pneumatic devices tend to be cheaper and more easily capable of controlling large rates of flow.
  - The main drawback with pneumatic systems is, however, the compressibility of air. This makes it necessary to have a storage reservoir to avoid changes in pressure occurring as a result of loads being applied.
  - Hydraulic signals do not have this problem and can be used for even higher power control devices.
  - They are, however, expensive and there are hazards associated with oil leaks which do not occur with air leaks

Advantages and Disadvantages of Pneumatic Actuators

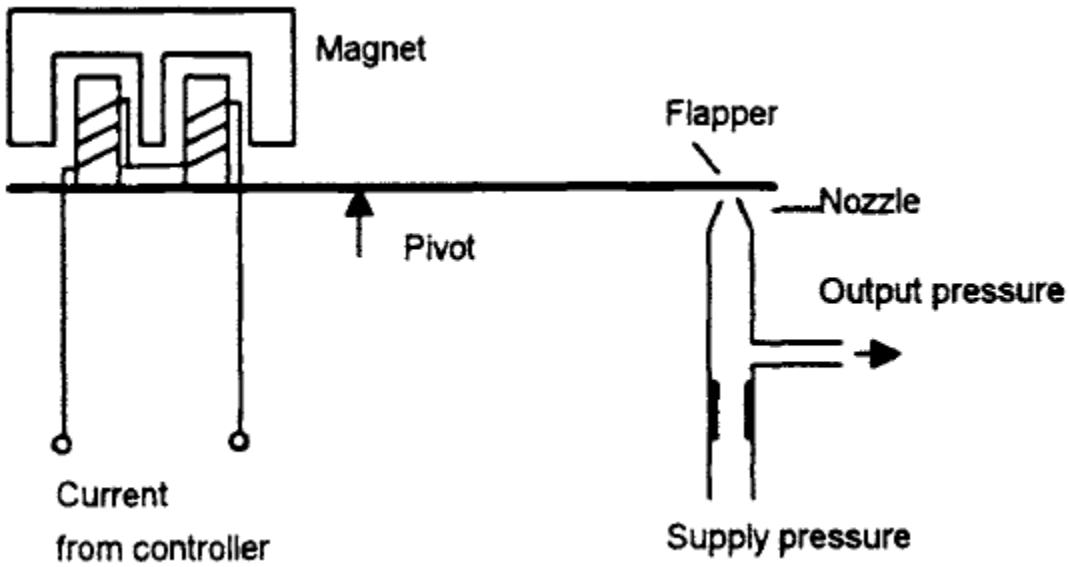
Advantages:

- low cost;
- high speed of moving;
- ease at reversion movements;
- high reliability of work;
- explosion and fire safety;
- ecological purity

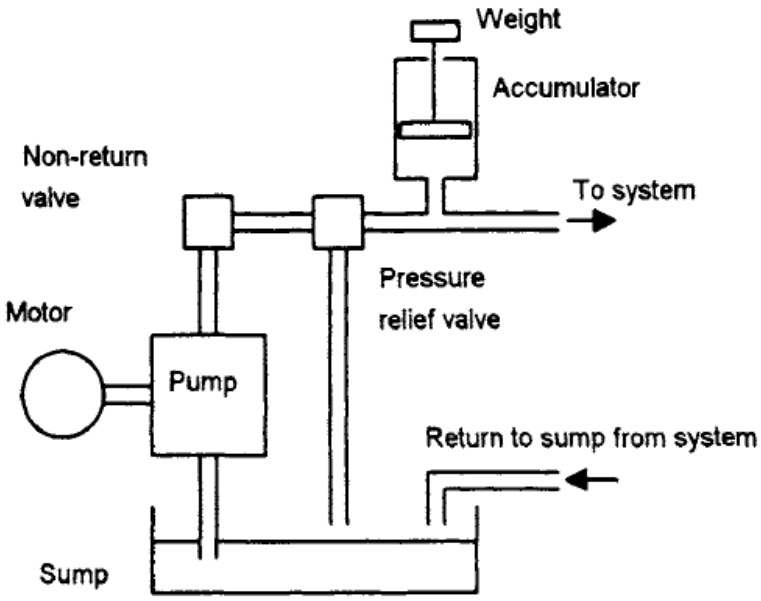
Disadvantages:

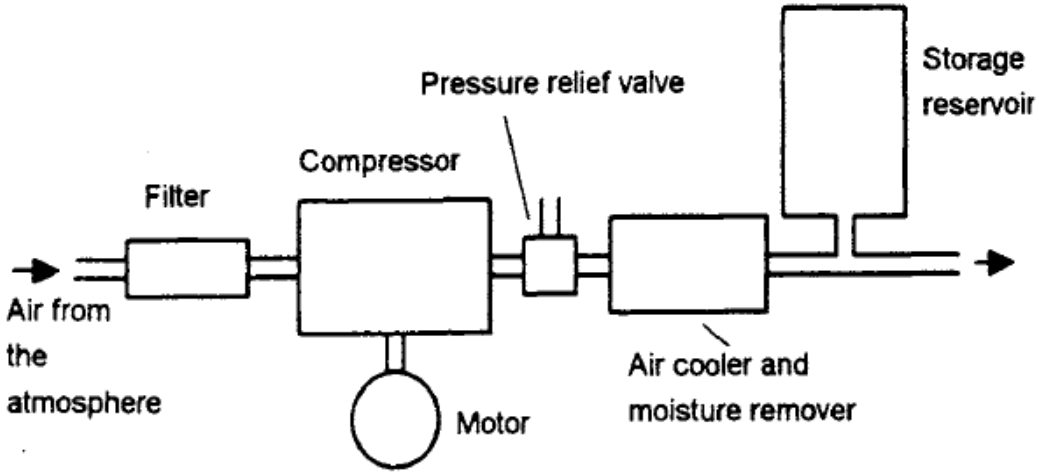
- compressibility of the air ;
- impossibility to receive uniform and constant speed of the working bodies movement
- difficulties in performance at slow speed
- limited conditions - use of compressed air is beneficial up to the definite values of pressure
- compressed air requires good preparation.

Current to Pressure (I/P) Converter



Actuating Sources (Pneumatic & Hydraulic)





Control Valves

- Pneumatic and hydraulic systems use control valves to give direction to the flow of fluid through a system, control its pressure and control the rate of flow. These types of valve can be termed *directional control valves, pressure control valves and flow control valves.*
  - ***Directional* control valves**, sometimes *termed as finite position valves because they are* either completely open or completely closed, i.e. they are on/off devices, are used to direct fluid along one path or another. They are equivalent to electric switches which are either ON or OFF.
  - **Pressure control valves**, often termed pressure regulator valves, react to changes in pressure in switching a flow on or off, or varying it.
  - **Flow control valves**, sometimes termed *infinite position valves, vary the rate at which a fluid passes* through a pipe and are used to regulate the flow of material in process control systems.

Fluid Power Actuators

- Fluid power actuators can be classified in two groups:
  - *linear actuators* which are used to move an object or apply a force in a straight line and
  - *rotary actuators which are used to move an object in a circular path*

Types of hydraulic actuator

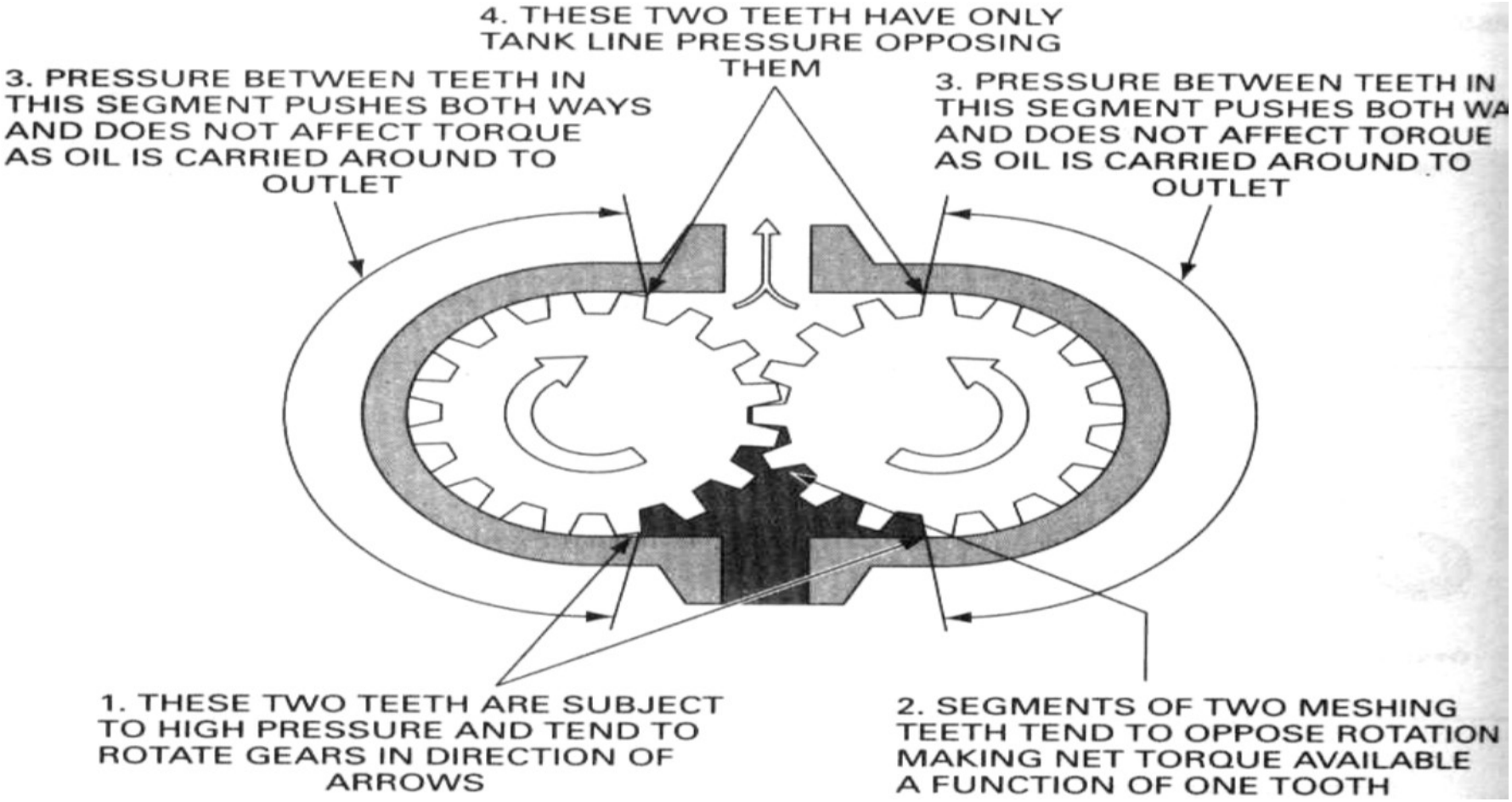
- Linear actuator (hydraulic cylinder)
  - Provides motion in straight line
  - Linear displacement depends on stroke length (length of actuator)
  - Usually referred to as cylinders, rams (single acting cylinders) or jacks (cylinder used for lifting)
- Rotary actuators (Hydraulic motors)
  - Produces continuous rotational motion
  - Pump shaft is rotated to generate flow, a motor shaft is caused to rotate by fluid being forced into the driving chambers

- Semi rotary actuators
  - Produces non-continuous rotational motion
  - Limited to less than one revolution (<360°)
  - Used to produce oscillatory motions in mechanisms.

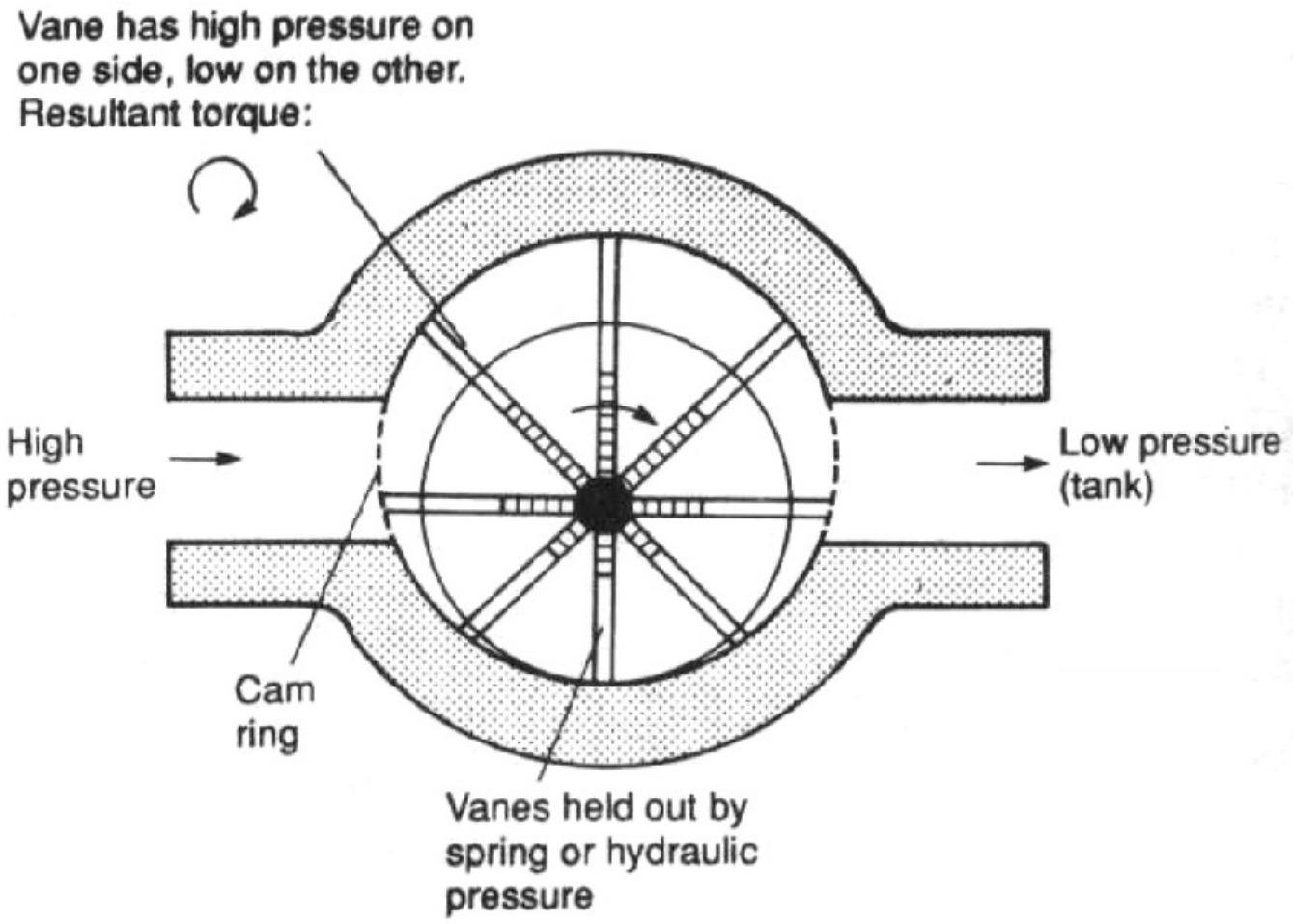
Rotary hydraulic actuators

- Gear motor
- Vane motor
- Swash plate type piston motor
- Bent-axis type piston motor

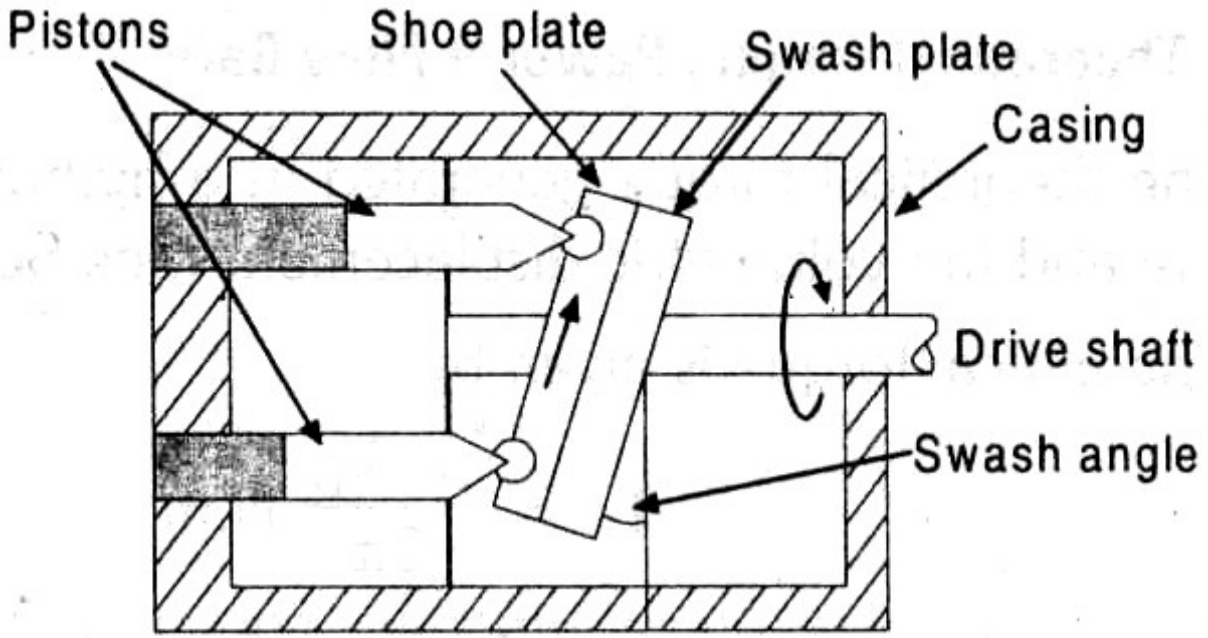
Gear motor


4. THESE TWO TEETH HAVE ONLY TANK LINE PRESSURE OPPOSING THEM
3. PRESSURE BETWEEN TEETH IN THIS SEGMENT PUSHES BOTH WAYS AND DOES NOT AFFECT TORQUE AS OIL IS CARRIED AROUND TO OUTLET
3. PRESSURE BETWEEN TEETH IN THIS SEGMENT PUSHES BOTH WA AND DOES NOT AFFECT TORQUE AS OIL IS CARRIED AROUND TO OUTLET
1. THESE TWO TEETH ARE SUBJECT TO HIGH PRESSURE AND TEND TO ROTATE GEARS IN DIRECTION OF ARROWS
2. SEGMENTS OF TWO MESHING TEETH TEND TO OPPOSE ROTATION MAKING NET TORQUE AVAILABLE A FUNCTION OF ONE TOOTH

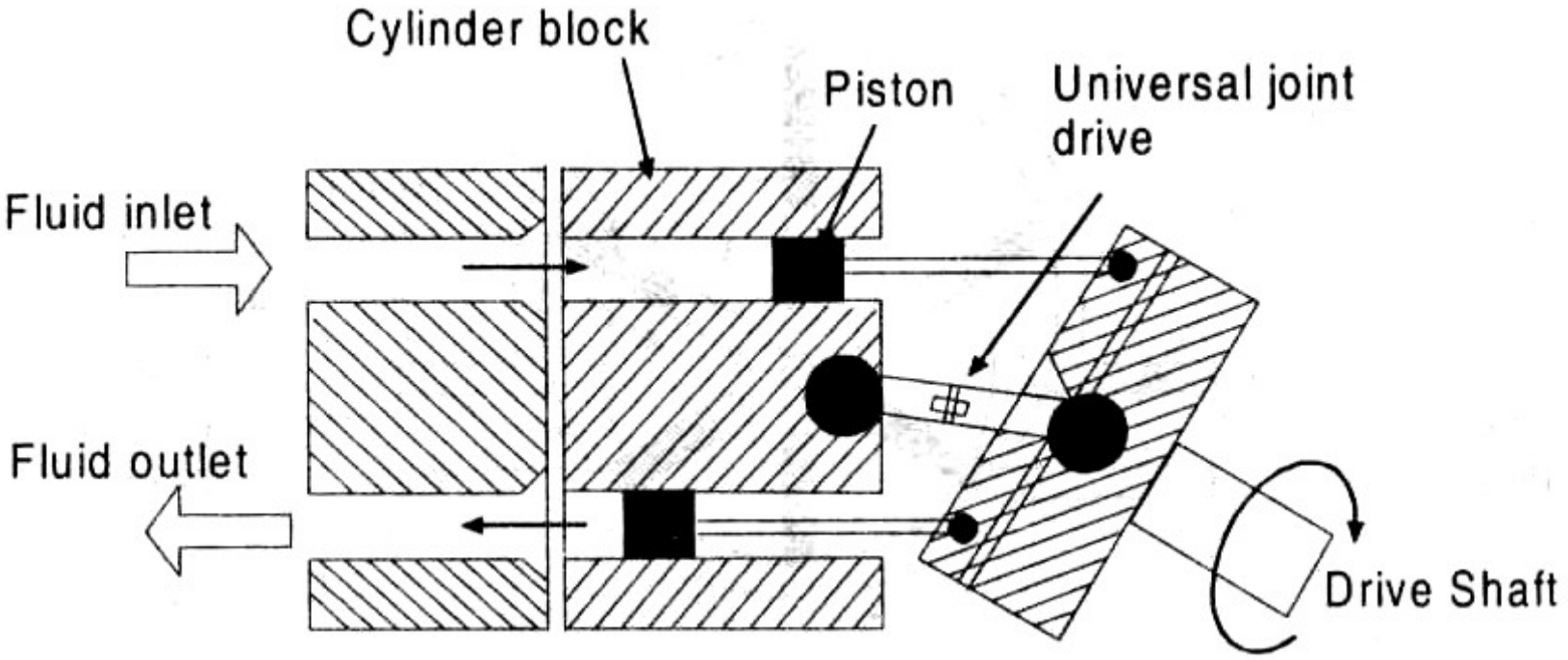
Vane motor


Vane has high pressure on one side, low on the other. Resultant torque:
High pressure
Low pressure (tank)
Cam ring
Vanes held out by spring or hydraulic pressure

Swash plate type piston motor



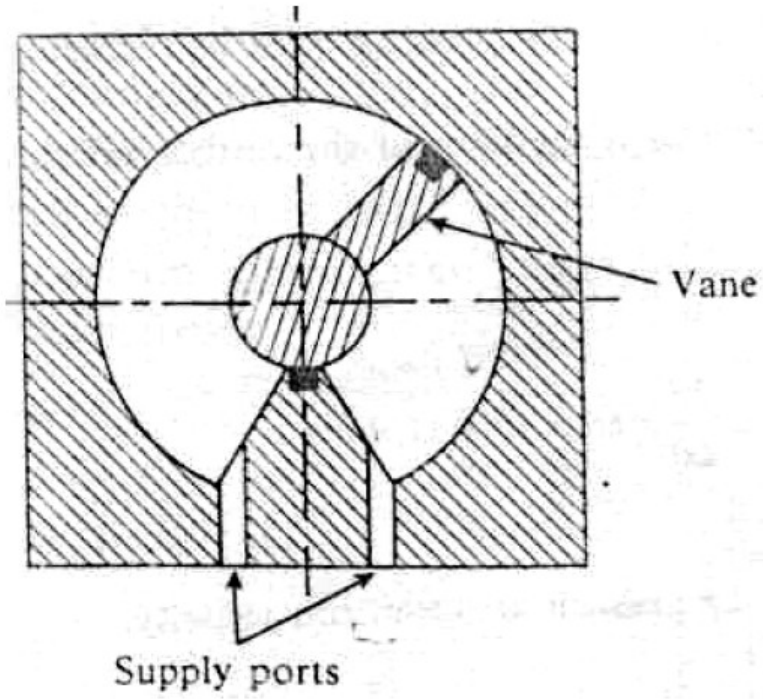
Bent-axis type piston motor



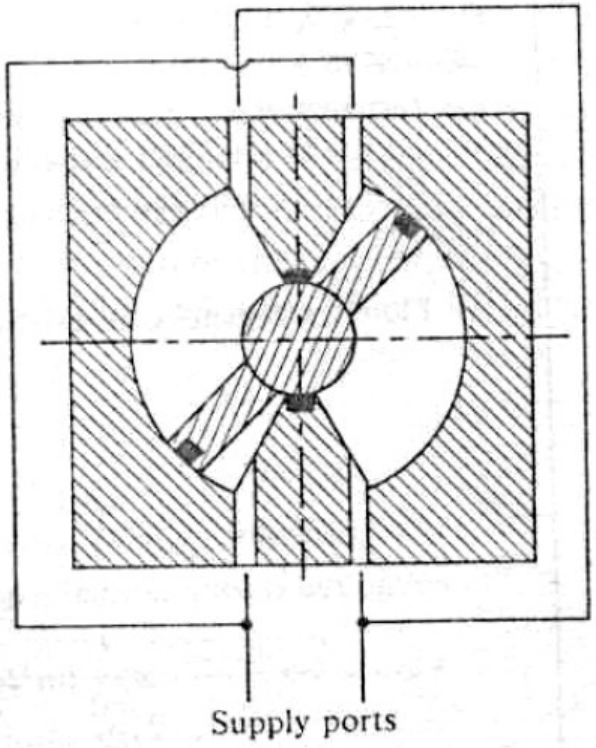
Semi rotary hydraulic actuators

- Vane actuator
- Piston types or lever arm actuator
- Rack and pinion actuator
- Chain and sprocket actuator
- Helical screw actuator

Vane actuator

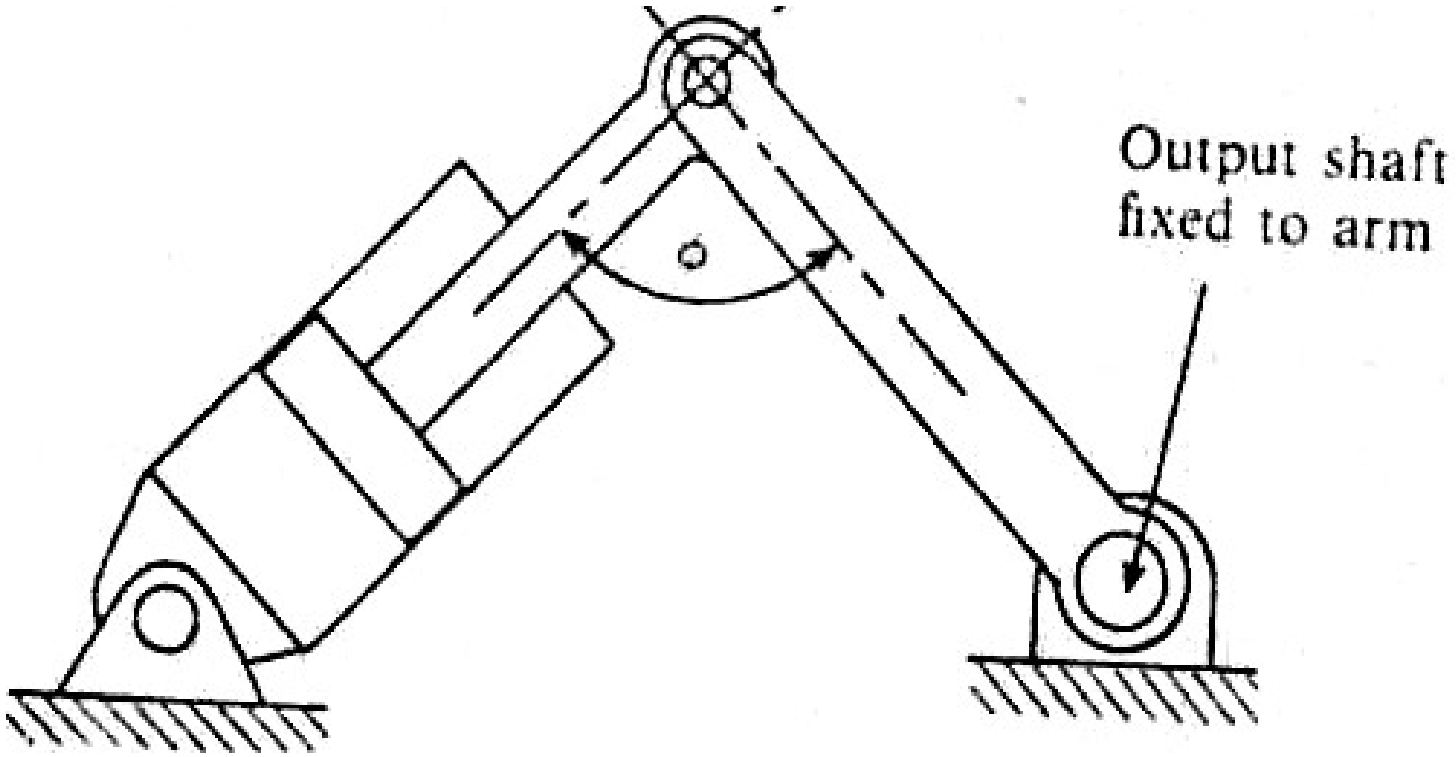


Single Vane

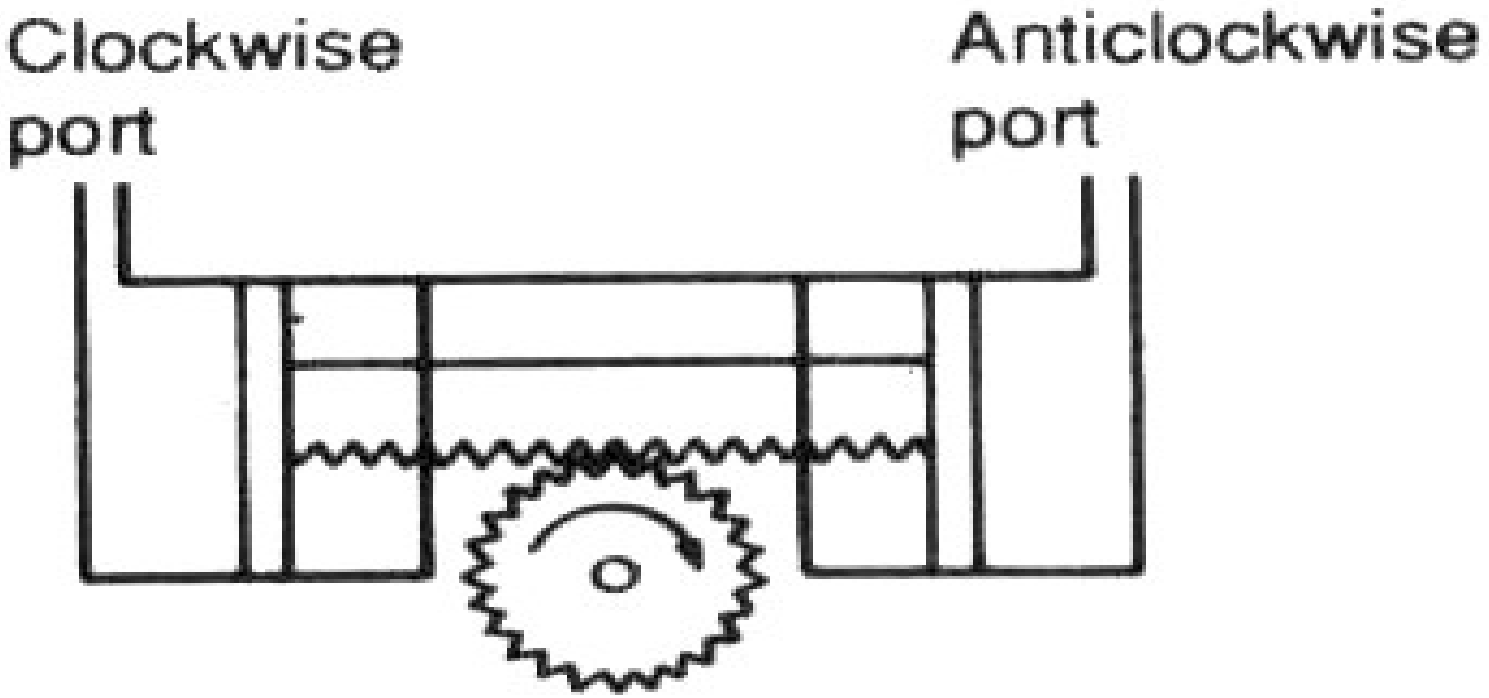


Double Vane

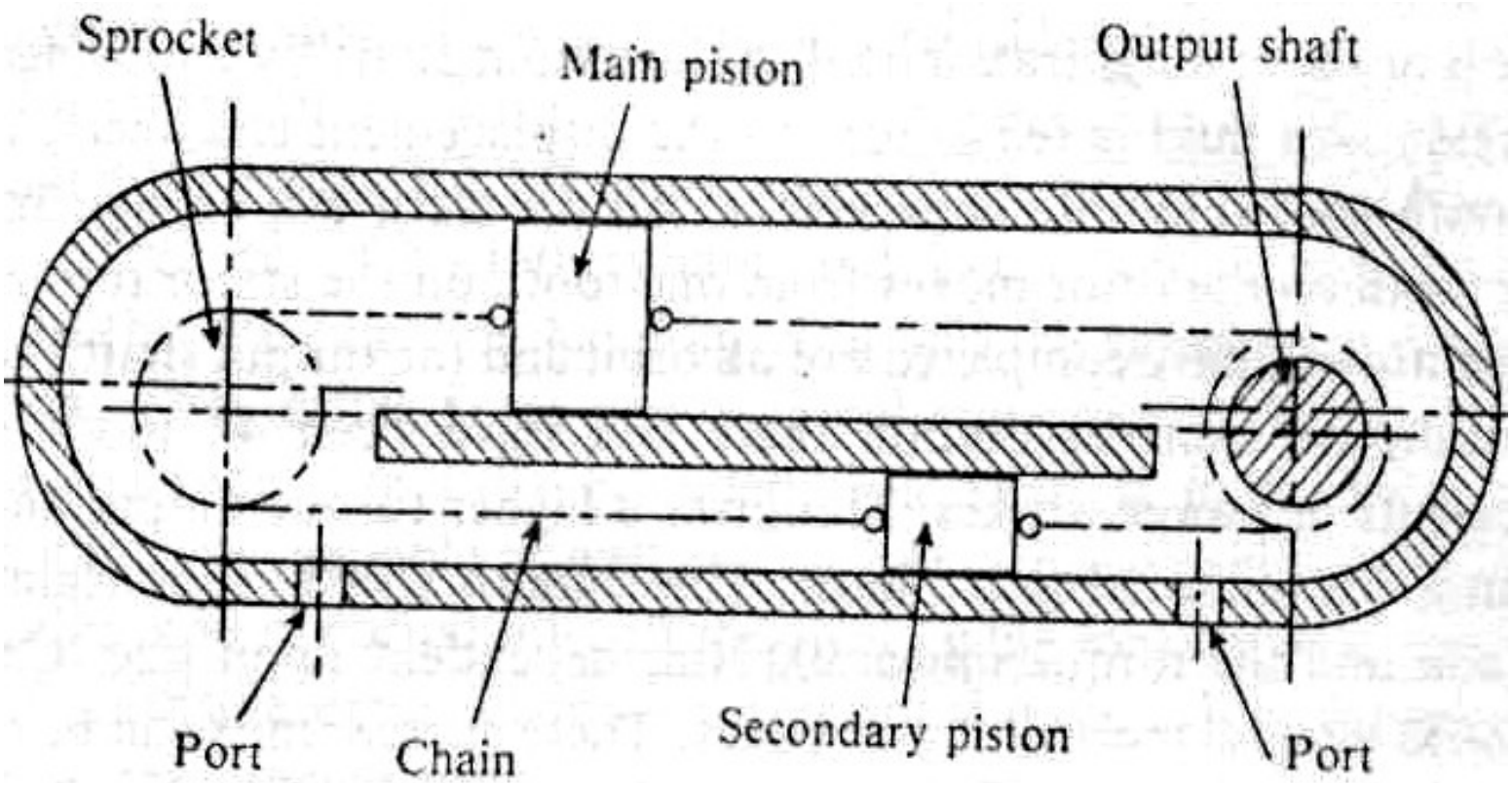
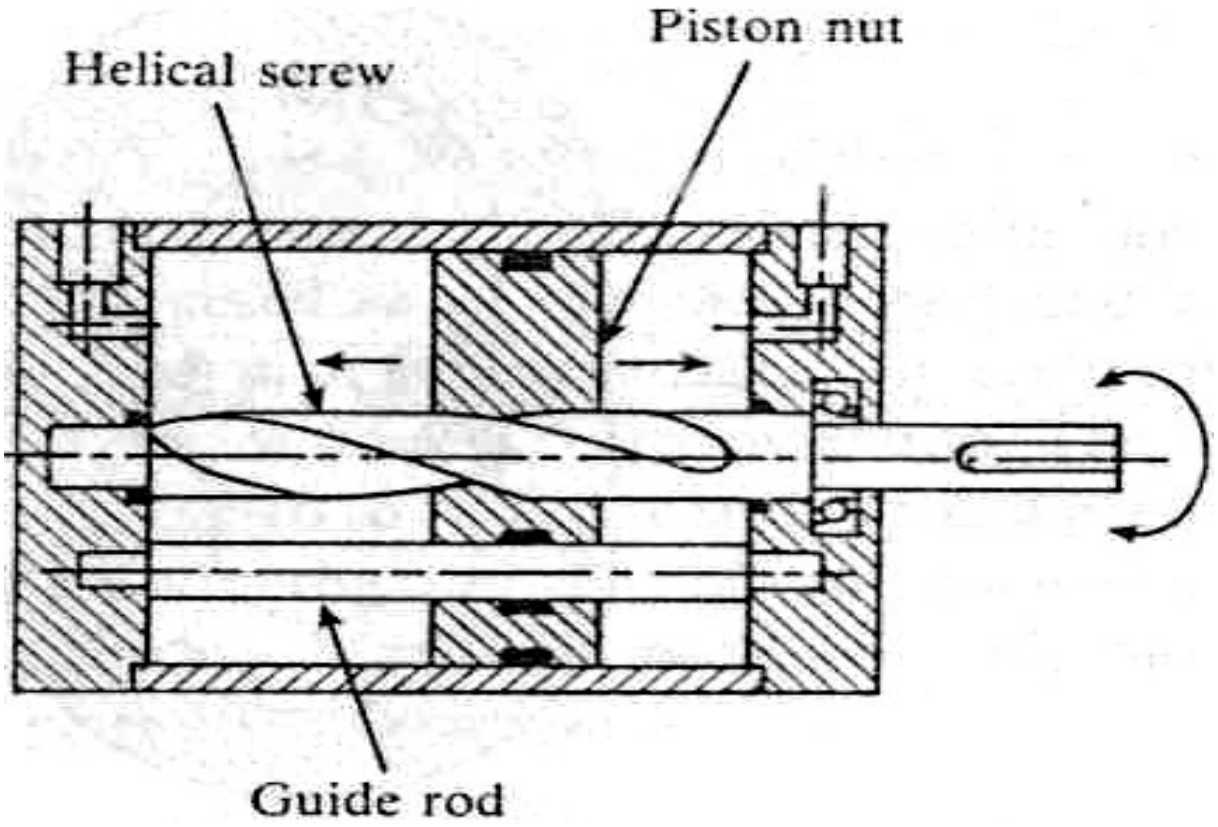
Piston types or lever arm actuator



Rack and pinion actuator



Chain and sprocket actuator



Helical screw actuator